Driver Cellphone and Texting Bans in the United States: Evidence of Effectiveness

Anne T. McCartt, Ph.D., David G. Kidd, Ph.D., Eric R. Teoh, M.S.
Insurance Institute for Highway Safety

ABSTRACT – Almost all U.S. states have laws limiting drivers' cellphone use. The evidence suggests that all-driver bans on hand-held phone conversations have resulted in long-term reductions in hand-held phone use, and drivers in ban states reported higher rates of hands-free phone use and lower overall phone use compared with drivers in non-ban states. Bans on all phone use by teenage drivers have not been shown to reduce their phone use. The effects of texting bans on the rates of drivers' texting are unknown. With regard to the effects of bans on crashes, 11 peer-reviewed papers or technical reports of all-driver hand-held phone bans and texting bans were reviewed. Some were single-state studies examining crash measures before and after a state ban; other national or multi-state studies compared crashes in states with and without bans over time. The results varied widely. The lack of appropriate controls and other challenges in conducting strong evaluations limited the findings of some studies. Thus, despite the proliferation of laws limiting drivers' cellphone use, it is unclear whether they are having the desired effects on safety. Priorities for future research are suggested.

INTRODUCTION

Strong laws with publicized strong enforcement are a proven countermeasure for changing driver behavior. This approach, for example, has led to increases in seat belt use [Dinh-Zarr, Sleet, Shults, et al., 2001; Tison, Williams, 2010], decreases in alcohol-impaired driving [Shults, Elder, Sleet, et al., 2001; Wells, Preusser, Williams, 1992], and ultimately reductions in crash deaths [Farmer, Williams, 2006; Dinh-Zarr et al., 2001; Shults et al., 2001]. As cellphones began to proliferate in the late 1990s, a number of experimental studies found decrements in simulated or instrumented driving performance associated with phone use [McCartt, Hellinga, Braitman, 2006], and a well-publicized epidemiological study found a fourfold increase in the risk of a property damage-only crash associated with a driver's phone conversation [Redelmeier, Tibshirani, 1997]. Bolstered by this research, concerns about the risks of drivers' cellphone use led to the passage of laws limiting use. These laws are widespread in other countries and are increasingly common in the United States. This paper summarizes the research on the effectiveness of these laws in the United States.

On November 1, 2001, New York became the first state to implement a law prohibiting all drivers from talking on a hand-held cellphone while driving. Currently a total of 12 states and the District of Columbia have such laws. All of the laws allow emergency calls, most allow hand-held dialing, and some allow talking when stopped in traffic, at controlled intersections, or on the side of the road. The language in early hand-held cellphone laws in Connecticut (effective October 1, 2005) and the District of Columbia (effective July 1, 2004) covered text messaging, but Washington enacted the first law specifically banning all drivers from texting, effective January 1, 2008. Many states rapidly followed suit, and currently 41 states and the District of Columbia prohibit texting by all drivers. Beginning with New Jersey on January 8, 2002, 37 states and the District of Columbia have implemented laws targeting teenage drivers. These laws generally prohibit any use of an electronic device/telecommunications device/ cellphone, whether hands-free or hand-held; the laws may be based on age (e.g., younger than 18) or license stage (e.g., learner's permit or intermediate license). Only three states — Arizona, Montana, and South Carolina — have no laws limiting drivers' cellphone use. Thus, currently there is a patchwork of laws limiting drivers' cellphone use across the United States. Appendix A summarizes the history of the all-driver hand-held cellphone laws, all-driver texting laws, and teenage driver cellphone laws, including effective dates and key provisions.

Conducting rigorous evaluations of highway safety laws can be challenging. Ideally, information can be obtained to measure meaningful changes in the targeted behavior following implementation of the law

CORRESPONDING AUTHOR:
Anne T. McCartt, Ph.D., Insurance Institute for Highway Safety, 1005 N Glebe Road, Arlington, Virginia 22201 United States; Email: amccartt@iihs.org

and corresponding changes in crashes, injuries, or fatalities. For the link between a law and crash outcomes to be convincing, there should be strong evidence of an elevated crash or injury risk associated with the targeted behavior, and the crash measure should be consistent with this evidence.

However, the crash risk associated with using a cellphone while driving is not well understood. Part of the challenge is that the contribution of phone use or other distractions to crashes is not fully or consistently recorded in databases of police-reported crashes [e.g., National Safety Council, 2013]. The chief problem is that drivers are unlikely to volunteer that they were using phones, especially if it is illegal, and there usually is no other evidence of phone use at the crash scene. In addition, reporting practices likely have changed as the issue of distraction has grown in prominence and as states have enacted laws limiting cellphone use and added codes for cellphone use to crash report forms.

Figure 1 plots the annual percentage of crash deaths coded as involving driver distraction during 1999-2012 in each of several states and nationally. These data come from the Fatality Analysis Reporting System (FARS), a national census of crashes that occur on public roads and result in at least one death within 30 days. There are large, unexplained differences among the states and year-to-year anomalies within some states. For example, during 1997-2007, the proportion of crash deaths coded as involving distraction was 45-63% in New Mexico and 6-26% in California. Even after coding changes were implemented in 2010 to address some of the reporting problems, anomalies and inconsistencies have persisted. Thus, data on cellphone-related crashes in crash databases do not provide a solid basis for establishing the prevalence of cellphone-related crashes, supporting epidemiological research on the risks of cellphone use, or evaluating the effectiveness of cellphone bans.

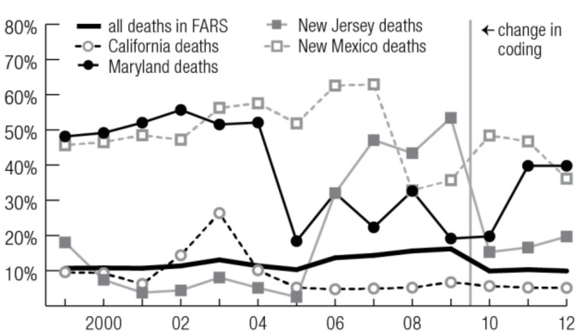

Figure 1. Percentage of Deaths in Crashes Coded as Involving Driver Distraction in the Fatality Analysis Reporting System, 1999-2012

Another challenge is that the findings from the few studies that have estimated crash risk associated with cellphone use are mixed. Two studies obtained cellphone billing records to verify phone use of drivers involved in property damage-only crashes [Redelmeier, Tibshirani, 1997] and in crashes serious enough to injure the drivers [McEvoy, Stevenson, McCartt, et al., 2005]. Using a case-crossover design, both studies found a fourfold increase in crash risk associated with phone conversations; the increased risk was similar for hands-free and hand-held phone use. Although the case-crossover designs accounted for possible driver differences, they assume the reasons for phone use are independent of crash risk, which may not be the case. Drivers with higher crash risk, who were more likely to get into the studies, may be affected by cellphone use differently than less risky drivers. Plus, the subjects may have had imperfect recall of whether or not they drove during control periods.

Young and Schreiner (2009) examined the call records of OnStar hands-free mobile phone customers and airbag deployments. Airbag deployment crash rates were not significantly different during periods when drivers were using the OnStar phone system compared with periods of non-use. As with the case-crossover studies, the reasons for phone use may not have been independent from crash risk, and the distribution of driving conditions for OnStar and non-calling minutes was unknown. The analysis did not account for periods when drivers may have been using their portable cellphones. It also was unclear if drivers who placed calls through the OnStar system while driving were different from those who did not.

The risk of cellphone use also has been examined in naturalistic studies that continuously videotape drivers and monitor their driving. Klauer, Dingus, Neale, et al. (2006) collected 1 year of data from 109 drivers and found that the risk of an at-fault crash or near-crash was 1.3 times as high when drivers were talking on hand-held phones and 2.8 times as high when drivers were dialing compared with just driving; the latter difference was significant. However, nearly 9 times as many near-crashes as actual crashes were observed, and only 17% of the crashes were reported to police [Dingus, Klauer, Neale, et al., 2006]. Based on a re-analysis of these data and an analysis of data from 42 newly licensed teenagers, the risk of an at-fault crash or near-crash among teenagers was significantly increased with dialing or reaching for a phone and with texting compared with just driving [Klauer, Guo, Simons-Morton, et al., 2014]. Among adult drivers, only dialing was associated with increased risk; texting was not assessed. Using near-crashes in addition to crashes to estimate risk may result in more conservative risk estimates than when using crashes alone [Guo, Klauer, Hankey, et al., 2010].

Fitch, Soccolich, Guo, et al. (2013) collected 1 month of data from 204 drivers who reported using phones daily while driving. The estimated risk of a crash, near-crash, or crash-relevant conflict was 21-27% lower when drivers were talking on a portable hand-held or hands-free cellphone compared with just driving, but these estimates were not significant. Risk was nearly twice as high when drivers engaged in visual/manual tasks such as dialing, texting, or reaching for a phone. Most of the 342 events were crash-relevant conflicts, and only 6 were crashes, including 2 curb strikes. It is unknown how well less severe crash surrogates such as crash-relevant conflicts predict actual crashes, especially serious ones.

Bhargava and Pathania (2013) examined patterns of cellphone use while driving and police-reported crashes around a common transition from peak to off-peak cellphone plan pricing at 9 p.m. Calls that were switched between towers were assumed to be made by drivers. Weekday rates of calls switching towers during 9-9:59 p.m. per traffic counts during 11 days in California in 2005 were 7.2 percentage points higher than the hour before, a significant increase. However, this uptick in cellphone use did not correspond with significant changes in crash counts in California and 8 other states between 9-9:59 p.m. and the hour before during 2002-05 compared with changes between these time periods in 1995-98 when cellphone use was scarce. Some calls would have been made by passengers (including mass transit riders), and treating all such calls as being made by drivers could be a problem if the relative cellphone behavior of drivers and passengers or the passenger occupancy rate varies by time of day.

On the issue of texting while driving, even less is known. There are no studies estimating actual crash risk associated with texting. Three naturalistic studies estimated the risk associated with texting, producing widely divergent estimates of risk. In a study of drivers who frequently used their phones while driving, the risk of a crash, near-crash, or crash-relevant conflict was about two times higher when drivers were texting compared with just driving or driving without using a phone [Fitch et al., 2013]. In a study of drivers of large trucks, the odds of a lane drift, traffic conflict, near-crash, or crash were 23 times as high when drivers were texting compared with just driving [Olson, Hanowski, Hickman, et al., 2009]. In both studies, actual crashes represented less than 2% of the incidents. It is unknown how less severe incidents relate to actual crashes or whether the results from either study generalize to the general population of drivers. A study of newly licensed teenagers found the risk of an at-fault crash or near-crash was 4 times as high when sending or receiving text messages compared with just driving [Klauer et al., 2014]. The sample included 31 crashes and 136 near-crashes.

The deleterious effects of cellphone use and texting on simulated or instrumented driving performance are well-established [Caird, Johnston, Willness, et al., 2013; Caird, Willness, Steel, et al., 2008; McCartt, Hellinga, Bratiman, 2006]. However, the absence of a thorough understanding of the crash risks associated with cellphone use and texting while driving has important implications for evaluating laws limiting drivers' cellphone use. Formulating careful hypotheses about the magnitude or direction of the effects of cellphone or texting bans and selecting appropriate crash outcome measures are challenging.

The current review focuses on studies published in peer-reviewed journals or as technical reports. Studies were identified through online databases (e.g. the National Academy of Science's Transportation Research Information Services (TRIS) database, ScienceDirect, Google Scholar, PubMed) using key word variants of mobile phone, cell phone, texting, legislation, and ban, and combinations of these keywords. Backward referencing was used to identify additional studies. Most of the studies identified were conducted in the United States, but there also were several studies of the effects of cellphone bans on driver behavior in other countries [e.g., Hussain, Al-Shakarchi, Mahmoudi, et al. 2006; Johal, Napier, Britt-Compton 2005; Rajalin, Summala, Pöysti, et al. 2005]. However, evaluations of the effects of cellphone laws on crashes were confined to U.S. studies. Therefore, this review is restricted to evaluations of U.S. cellphone legislation.

STUDIES OF ALL-DRIVER HAND-HELD CELLPHONE BANS

Effects on Rates of Hand-held Cellphone Conversations

There is evidence that all-driver bans on hand-held phone conversations can have large and lasting effects on drivers' behaviors. The percentage of drivers talking on hand-held phones was measured before and after bans took effect in Connecticut, the District of Columbia, and New York and in control jurisdictions without bans [McCartt, Hellinga, and Strouse, et al., 2010]. Driver hand-held phone use was estimated to be 24-76% lower up to 7 years after the bans were implemented than would have been expected without the bans. The authors reported that in all three jurisdictions, the chance that violators would receive citations was low, and there were no publicized sustained enforcement campaigns.

In a 2009 national telephone survey, 56% of drivers in states with all-driver hand-held phone bans reported using any type of phone when driving compared with 69% in states without such laws [Braitman, McCartt, 2010]. The proportion of drivers who talked on phones and always talk hands-free was 22% in states with bans and 13% in states without bans.

High-visibility enforcement has been shown to increase compliance with traffic laws [Dinh-Zarr et al., 2001;Wells et al., 1992]. After programs of publicized high-intensity enforcement of all-driver hand-held phone and texting bans were implemented, the rate of observed hand-held phone conversations declined by 57% in Hartford, Conn., a significant change, while rates did not change significantly in a control community [Cosgrove, Chaudhary, Reagan, 2011]. Rates declined by 32% in Syracuse, N.Y., and by 40% in a control community; both changes were significant. A recent survey of state highway safety offices found that states increasingly are conducting heightened enforcement of cellphone and texting bans [Governor's Highway Safety Association, 2013]. States also reported that police officers are challenged by bans applying only to teenage drivers; secondary enforcement laws that require police to have some other reason to stop a vehicle before citing the driver for violating the cellphone law; and the difficulty of discerning whether a motorist is engaged in an illegal behavior such as texting as compared with a behavior that is permitted such as dialing a phone.

Effects on Crash Outcomes

Thirteen studies of the effects on crashes of all-driver bans on hand-held cellphone conversations were identified. Three were working papers [Burger, Kaffine, Yu, 2013; Cheng, 2012; Rocco, Sampaio, 2012], one was a memo [Ragland, 2012], and the remaining nine were published in peer-reviewed journals [Anyanwu, 2012; Bhargava, Pathania, 2013; Jacobson, King, Ryan, et al., 2012; Kolko, 2009; Lim, Chi, 2013a; Lim, Chi 2013b; Nikolaev, Robbin, Jacobson, 2010; Sampaio, 2010; Trempel, Kyrychenko, Moore, 2011]. The following summary focuses on the peer-reviewed papers.

State-specific Studies. Four studies examined crashes in individual states with all-driver hand-held cellphone bans. State-specific studies can be strong designs if they have a large sample of crashes with multiple data points before and after the ban, account for time trends in crashes, and incorporate a reasonable control group (usually a neighboring state) to account for crash trends associated with economic factors and other unobserved factors. Although some studies of countermeasures use within-state crash controls (e.g., crashes of middle-aged drivers as a control for teenage driver crashes), this is infeasible when evaluating cellphone bans as crashes that are or are not cellphone-related cannot be identified reliably.

Trempel et al. (2011) studied bans implemented in California, Connecticut, the District of Columbia, and New York. Poisson regression was used to examine monthly insurance collision claim rates (per insured vehicle year) 18-33 months before and 12-29 months after the bans took effect. Collision claims cover first-party physical damage to a vehicle from a crash. Collision claim rates in at least two neighboring states were used as controls for each ban state. There were non-significant small reductions in claim rates in California and the District of Columbia associated with the phone bans, and small but significant increases in Connecticut and New York. Separate analyses found no significant effects for drivers younger than 25 in each ban jurisdiction.

Trempel et al. (2011) noted that the findings were surprising in light of the large observed decrease in hand-held phone use after bans were implemented in three of the four jurisdictions studied, and the national survey data indicating not all drivers in ban states switch to hands-free phones. The collision claims database does not include information on crash-involved drivers' phone use. However, collision claims data are dominated by low-severity property-damage crashes, similar to the crashes studied by Redelmeier and Tibshirani (1997), who found a four-fold increase in crash risk associated with phone conversations. Given this large increase in crash risk combined with the large reductions in observed hand-held phone use, reductions in total crashes would have been expected. The study used multiple neighboring control states to account for other factors that potentially affected collision claim rates, but it is unknown to what extent these other factors were accounted for. For instance, Trempel et al. did not account for changes in other highway safety laws in control and treatment states during the study periods. They also included collision claims data only from recent model year vehicles, which may not represent the crash experience of older vehicles.

A series of three studies focused on the effects of New York's hand-held cellphone ban, using annual county-level data on fatal crashes and injury crashes.

Nikolaev et al. (2010) examined the mean annual rate of fatal crashes per 100,000 licensed drivers and injury crashes per 1,000 licensed drivers in each county and statewide before (1997-2001) and after (2002-07) the ban took effect in November 2001. The authors reported significant reductions in mean crash rates in most counties and statewide. For example, the mean annual rate of injury crashes per licensed driver declined significantly in 46 of the 62 counties. However, there was no control group or attempt to control for unrelated crash trends, so it is unclear how much of the change can be attributed to the hand-held cellphone ban.

Using the same annual New York data, Sampaio (2010) sought to address limitations in the Nikolaev et al. (2010) study. Sampaio included fatal crash data from Pennsylvania counties, a state with no ban during the study period, in the analysis to account for unrelated crash trends and allowed for county differences. The analyses found a reduction in fatal crash rates between the pre-ban period and post-ban period that was significantly greater in New York compared with Pennsylvania. Sampaio's approach was stronger than that of Nikolaev et al. because it included a control state and modeled annual crash trends, but it still had limitations. Because fatal crash rates were calculated and then modeled, it does not appear that variation in county size was taken into account in the model estimation.

In the third study, Jacobson et al. (2012) examined the effects of New York's ban on the rate of injury crashes per licensed driver, using county-level data from New York and Pennsylvania during 1997-2008. Regression models were developed for three driver density groups of counties, based on the number of licensed drivers per roadway mile. The New York City boroughs and counties encompassing national parks and wilderness areas were excluded. The authors concluded that there was a significant increase in crash rates at the onset of the ban for urban/suburban and very rural counties, and a significant decreasing trend in injury crash rates during the years following the ban as compared with the years before the ban for urban/suburban and rural counties, relative to the contemporaneous changes in Pennsylvania. Jacobson et al. did not provide an empirical or theoretical reason to support their method of categorizing counties into driver density groups, so the mechanism underlying the varying effectiveness of New York's ban across counties of varying driver density is unclear. However, the findings suggest the relationship of driver density and the effects of bans on crashes may bear further study.

It is important to note that New York's hand-held cellphone ban was implemented shortly after the September 11, 2001 terrorist attacks. The economic impact of this event may have affected travel patterns and crash rates in New York and may make it difficult to isolate the effects of the ban on crash rates, at least in the short-term. This potential limitation affects all studies of the New York ban.

National Studies. Six studies compared fatal crash measures over time in states with and without all-driver hand-held cellphone bans. Two studies focused solely on the effects of all-driver hand-held phone bans [Kolko, 2009; Lim, Chi, 2013a]; the other four also examined the effects of texting and/or teenage driver phone bans [Anyanwu, 2012; Cheng, 2012; Lim, Chi, 2013b; Rocco, Sampaio, 2012]. Lim and Chi (2013b) focused on the effects of all-driver hand-held cellphone bans and teenage driver cellphone bans on crashes involving teenage drivers; this study is discussed in a later section of this paper.

The national studies vary with regard to the fatal crash measures, whether state or county data are analyzed, the frequency of data points, the study periods, and there may have been different interpretations of law provisions and effective dates. Some examined only certain types of bans (e.g., primary enforcement bans, which allow police to stop vehicles solely for cellphone law violations) or compared the effects of different provisions (e.g., teenage driver laws based on age vs. driver license stage). The studies used different exposure measures (e.g., number of licensed drivers, vehicle miles traveled) and may have accounted for these differently (e.g., modeling crash rates or using the exposure measure as a covariate). Generally, however, the studies took a similar approach, using models that compared changes in crash measures over time in states with and without bans while controlling for time trends and other factors hypothesized to affect general crash trends (e.g., unemployment rates, state maximum speed limits, gas prices). All of the national studies used fatal crash data. This is likely because the only public national databases of non-fatal crash data are samples that cannot be disaggregated by state. However, the number of fatal crashes in some states is small and even smaller when crash data are examined at the county and/or monthly level.

National studies often incorporate time-varying variables to account for unobserved factors that might influence crash trends differently in different jurisdictions. Selecting these variables can be challenging, especially during a time period that includes several years of substantial declines in fatal crashes as well as a deep economic recession and volatile gas prices, both factors known to have complex effects on driving exposure and crashes. In addition, not all studies accounted for state differences in highway safety laws known to influence fatal crashes and fatalities, or texting laws, for example. Regardless, national studies are much less straightforward than single-state studies with reasonable control jurisdictions, and it is always uncertain whether the appropriate covariates have been identified. Although all the national studies share some of these limitations, the three peer-reviewed ones are discussed below.

Kolko (2009) examined whether rates of cellphone ownership and all-driver hand-held cellphone bans were associated with monthly annual rates of crash deaths per billion vehicle miles traveled across the 48 contiguous states and the District of Columbia during 1997-2005. As information about cellphone use while driving was not available, state-level data on the percentage of households with cellphones was used as a surrogate. Cellphone ownership was positively associated with the monthly annual fatality rate, and hand-held cellphone bans were negatively associated. However, these associations were not significant after controlling for other factors that could influence crash trends (e.g., weather, unemployment rate) and time and state fixed effects. Subsequent models examined monthly fatality rates in various roadway and weather conditions. Higher mobile phone ownership was significantly associated with higher fatality rates in bad weather or wet road conditions, and hand-held cellphone bans were significantly associated with lower fatality rates in these same conditions. The author acknowledges several limitations, including the lack of data on vehicle miles traveled in specific driving conditions and the fact that cellphone ownership rates may be unrelated to actual use while driving. Only four states had all-driver hand-held cellphone bans during the study period, and three of the bans took effect near the end of the study period so that the longer term findings were primarily based on fatality rates in New York.

Lim and Chi (2013a) used state-level annual fatal crash data during 2000-10 to study the effects of all-driver hand-held cellphone bans with primary enforcement on fatality rates per miles traveled, fatality rates per capita, and the total number of drivers and number of drivers in different age groups in fatal crashes. Fatality rates per miles traveled and per capita did not change significantly after states enacted bans with primary enforcement when accounting for other variables that may be associated with crash trends (e.g., speed limit, gas prices, unemployment rate), yearly trends in crash rates, and variation in rates between states. All-driver hand-held cellphone bans allowing primary enforcement were associated with a significant reduction in the total number of drivers and the number of drivers in the age groups younger than 55 involved in fatal crashes. However, these latter analyses had several notable limitations. The reduction observed for the youngest driver age groups was confounded by variations in teenage driver licensing laws among and within states over time that have been shown to be associated with fatal crash rates. Finally, the control group for the analyses included states with cellphone laws; for example, three states had all-driver hand-held cellphone laws with secondary enforcement at some point during the study period.

Anyanwu (2012) used state-level annual fatal crash data during 2000-09 to study the effects on crash fatalities of all-driver hand-held cellphone bans, all-driver texting bans, bans that prohibit drivers younger than 20 from using cellphones, and bans that restrict intermediate license holders from using cellphones. States with all-driver hand-held cellphone bans had significantly fewer fatalities than states without bans after controlling for the overall licensed driver population, licensed teenage population, the ratio of male to female licensed drivers, state personal income, and state and year fixed effects. No significant effects on the number of fatalities were found for the other types of laws. However, cellphone bans were not correctly coded based on the definitions the authors provided. For example, Connecticut and the District of Columbia implemented laws prohibiting drivers from texting in 2005 and 2004, respectively, but Anyanwu reports that no states had texting bans prior to 2008. Also, no state banned all drivers younger than 20 from using a cellphone while driving during 2000-09; rather, states did restrict some drivers younger than 20 from cellphone use (e.g., drivers 17 and younger). Finally, the statistical model included only a few control variables and may not have adequately accounted for unobserved factors that influence driving habits and crash fatalities (e.g., unemployment, vehicle miles traveled).

Multi-state Study. In their study of the relationship between drivers' phone use rates and crashes, Bhargava and Pathania (2013) conducted analyses that examined state-level monthly fatal crashes per 100,000 persons before and after all-driver hand-held bans were implemented in New York, New Jersey, Connecticut, the District of Columbia, and Chicago. The possible influence of increased cellphone ownership during 1989-2007 on crash rates was modeled by comparing crash rates during 1989-1993, a period when cellphone use was scarce, with crash rates during 2001-07, when cellphones were more common. Crash rates were not significantly different after the bans were implemented across these states when controlling for cellphone ownership, highway traffic volume, and state and time-varying effects. Although 1989-1993 is a period with far less cellphone ownership relative to 2001-07, it does not account for other period-relevant factors (e.g., vehicle safety, highway safety laws) that influence fatal crashes.

STUDIES OF TEXTING LAWS

Evaluations of texting laws face the challenges confronted in evaluating hand-held cellphone laws but also additional ones. There is little reliable evidence on the prevalence of drivers' texting, and, as discussed above, little evidence about the crash risk associated with drivers' texting. In addition, the recent rapid enactment of texting bans has made it difficult to identify control states without bans and adequate after-ban study periods.

Effects on Rates of Texting

Because it is difficult for roadside observers to differentiate texting from other phone manipulations, observation surveys of drivers generally combine texting with other types of phone manipulations (e.g., dialing, browsing phone contact list), which are typically allowed under all-driver texting bans and hand-held cellphone bans. The best information suggests that texting is much rarer than phone conversations. A national observational survey of drivers stopped at intersections during the day in 2011 estimated that 1.3% of drivers were visibly manipulating hand-held devices and 5% were talking on hand-held phones [Pickrell, Ye, 2013].

There is scant evidence of the effects of texting bans on the rates of drivers' texting. Observation surveys of drivers conducted before and after texting bans in New York [Institute for Traffic Safety Management and Research, 2012] and Southern California [Block, personal communication, July 16, 2013] found that rates of texting increased after the bans. Observations were not conducted in control jurisdictions without texting bans, however, so that it is unclear whether rates were different than would have been expected without the bans. A 2009 national telephone survey of drivers found no significant association between frequency of texting and state texting bans. For example, among 18-24 year-olds, 45% reported texting while driving in states with all-driver texting bans, just shy of the 48% of drivers who reported texting in states without bans [Braitman, McCartt, 2010].

The difficulty of detecting a driver texting as compared with other types of phone manipulations makes it difficult to enforce texting laws, even when the laws allow primary enforcement. Despite this challenge, rates of observed manipulation of hand-held phones declined in two communities following publicized, high-intensity enforcement campaigns [Cosgrove et al., 2011]. The rate declined by 72% in Hartford, Conn., and 32% in Syracuse, N.Y., both significant changes, while the rates in the control communities did not change significantly.

Effects of on Crash Outcomes

Five studies evaluating the effects of texting bans on crash measures were identified. Of the five studies, two were published in a peer-reviewed journal [Abouk, Adams, 2013; Anyanwu, 2012], one was a published technical report [Highway Loss Data Institute (HLDI), 2010], and two were working papers [Cheng, 2012; Rocco, Sampaio, 2012].

HLDI (2010) conducted separate analyses of insurance collision claim rates in four states (California, Louisiana, Minnesota, Washington) before and after all-driver texting bans became effective, relative to claim rates in neighboring states that either had no ban or had no substantial change in their ban during the study period. Poisson regression was used to examine monthly collision claim rates (per insured vehicle year) 6-18 months before and 12-24 months after the bans took effect. Demographic variables were included in the models to control their effects on trends in collision claims experience. As with Trempel et al. (2011), a strength of the study was the use of collision claims data from at least two neighboring states to control for other unobserved factors.

In California, Louisiana, and Minnesota, there were significant modest increases in collision claim rates after the bans took effect, relative to the control states [HLDI, 2010]. Similar and significant increases also were found for drivers younger than 25 in these three states. In Washington there was essentially no change in claim rates. The study notes that the difficulty of enforcing texting bans and, perhaps, lack of compliance may explain in part why collision claim rates did not decrease following the bans. As for the increase in collision claim rates observed in three states, the report suggested texting drivers may have responded to the bans by hiding their phones from view, thereby increasing the potential danger. However, there is no self-report or field data to suggest that drivers were reacting to texting bans in this manner. As acknowledged by the authors, collision claims may not be a good indicator of crashes involving distraction. Although collision claim trends in the control states prior to the bans appeared similar to trends in the ban states, it is unknown whether the control states fully accounted for the unobserved factors influencing trends in claim rates in the ban states.

The four other studies of texting bans are cross-sectional national studies that modeled data on fatal crashes and/or crash deaths in states with and without texting bans. Of the four studies, two were peer-reviewed. Abouk and Adams (2013) classified texting bans as weak (secondary enforcement or covering only young drivers) or strong (primary enforcement, all-driver bans) and focused on monthly single-vehicle, single-occupant fatal crashes during 2007-10. They argued that these crashes are most likely to involve drivers sending text messages and are sensitive to the effects of a ban, although they offered no evidence for this contention. Various models estimated different effect sizes but consistently found the number of single-vehicle, single-occupant fatal crashes was lower in states with strong texting bans compared with states without texting bans, after controlling for demographic and economic factors. Other analyses found that single-vehicle, single-occupant fatal crashes were higher in states that implemented weak bans compared with control states and that the effects of strong texting laws were amplified in states with hand-held phone bans.

Some limitations call the findings of Abouk and Adams (2013) into question. The analyses do not include an appropriate within-state control group. Rather, results from a sensitivity analysis with counts of multiple-vehicle or multiple-occupant fatal crashes as a covariate were used as evidence that the decrease in single-vehicle, single-occupant fatal crashes was robust to within-state factors that might have influenced crash trends. However, this is not a convincing control group because multiple-vehicle or multiple-occupant fatal crashes also could involve texting drivers. In addition, there were several errors in the information on state ban provisions and effective dates, leading to multiple mistakes in the classification of state bans.

As described above, Anyanwu (2012) used state-level annual fatal crash data during 2000-09 to study the effects on crash fatalities of all-driver hand-held cellphone bans, all-driver texting bans, bans that prohibit drivers younger than 20 from using cellphones, and bans that restrict intermediate license holders from using cellphones. No significant effects on the number of fatalities were found for texting bans. As noted above, the study had several important limitations.

EFFECTS ON CELLPHONE AND TEXTING BANS ON TEENAGE DRIVERS

As summarized in Durbin, Fisher, McGehee, et al. (in press), little research has examined state cellphone bans focusing specifically on teenagers. A pair of studies found that North Carolina's teenage cellphone ban had no immediate or longer term effect on the observed rate of teenage drivers' cellphone use [Foss, Goodwin, McCartt, 2009; Goodwin, O'Brien, Foss, 2012]. The authors hypothesized that the lack of special enforcement initiatives and the small number of citations issued were factors. Laws targeting specific age groups or license status can be difficult to enforce.

Lim and Chi (2013b) attempted to isolate the effects of cellphone bans with primary enforcement on the number of drivers younger than 21 in fatal crashes not involving alcohol during three study periods (1996-2010, 1998-2010, and 2000-10), using state-level annual panel data. In one set of analyses, there were significantly fewer young driver fatal crash involvements in states with all-driver hand-held phone bans with primary enforcement than in states without these bans, but no effects were found for teenage driver bans. However, the study appeared to have important limitations, such as not accounting for state-specific time trends or changes in exposure among teenage drivers during the study period, including states that implemented cellphone bans with secondary enforcement as controls, and short follow-up periods for many bans. There are no published studies examining the effects of texting bans on teenage drivers' rates of texting or teenagers' crash rates.

CONCLUSIONS

Well-enforced traffic laws have been a highly effective countermeasure for reducing risky driving behaviors and the associated crashes, deaths, and injuries [Dinh-Zarr et al., 2001; Shults et al., 2001; Wells et al., 1992]. However, it is not clear at this point that laws limiting drivers' cellphone use are having the same beneficial effects. A review of the research on the effects of driver cellphone and texting bans found mixed results. As discussed throughout the review, there is considerable unsettled evidence with regard to the patterns of drivers' phone use or the effects of use on crash risk. Without this information, it is difficult to develop reasonable hypotheses about the expected effects of cellphone bans on crashes, or to choose appropriate crash outcome measures. Evaluations of cellphone and texting bans also must grapple with substantial methodological and data-related challenges that many of the reviewed studies were unable to overcome.

One of the strongest studies found no reductions in collision claim rates associated with all-driver hand-held bans in four states [Trempel et al., 2011], despite evidence of reduced hand-held cellphone use in three of the states [McCartt et al., 2010]. A study of texting bans using an analogous approach found modest but significant increases in collision claim rates in three states and no change in a fourth state [HLDI, 2010]. Other studies that appeared to have important limitations found reductions from bans [e.g., Abouk, Adams, 2013; Kolko, 2009; Nikolaev et al., 2010]. The findings of studies without appropriate crash measures and controls cannot be relied on.

Thus, even as states increasingly are enacting laws limiting drivers' phone use, it is unclear the laws will have the desired effect on crashes. Understanding the effectiveness of cellphone and texting bans is essential because states increasingly are expending resources on enacting, enforcing, and publicizing them [Governor's Highway Traffic Safety Association, 2013], and it is important that limited resources be directed to proven countermeasures with the greatest potential impact on safety.

RESEARCH PRIORITIES

An incomplete understanding of the crash risks associated with phone use makes it difficult to identify appropriate crash measures for evaluating cellphone and texting bans. It is believed that the following research could help address this problem:

- Strong studies of the crash risks associated with phone use that address the limitations of prior epidemiological crash-based studies and naturalistic studies, and that examine crashes of various severities, including serious crashes;
- Stronger studies validating associations of non-crash surrogates (e.g., crash-relevant conflicts) observed in naturalistic studies with crashes of different severities, including serious crashes.

Future evaluations of cellphone and texting laws should overcome the numerous challenges and address the limitations present in much of the existing research. Therefore, a third research priority is as follows:

- Additional well-controlled evaluations of cellphone and texting laws that include assessments of their effects on driver behavior and on crashes of various severities.

Future evaluations of cellphone bans should link specific changes in driver behavior to changes in crashes and should examine a fuller range of the effects of bans on behavior, such as the type of phone use (e.g., texting, conversation), phone type (e.g., hands-free, hand-held), or circumstances of use (e.g., stationary vehicle, moving vehicle). Evaluations of the effects on crashes should use crash measures that make sense based on studies of crash risk. They need to include appropriate controls to account for changes in other highway safety legislation during the study period, existing cellphone bans, and unobserved variables that can influence crash trends.

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APPENDIX A

Effective Date(s) and Enforcement Type(s) of U.S. States' All-driver Bans on Hand-held Cellphone Conversations and Texting Bans and Teenage-driver Bans on All Cellphone Use and Texting, as of January 2014

	All-driver ban		Teenage-driver ban	
	Hand-held cellphone conversations	Texting	Any hand-held and hands-free cellphone use	Texting
Alabama	—	8/1/2012	7/1/2010 (S) [A,L]	7/1/2010 (S) [A,L]
Alaska	—	9/1/2008	—	—
Arizona	—	—	—	—
Arkansas	—	10/1/2009	10/1/2009 (S) [A]	—
California	7/1/2008	1/1/2009	7/1/2008 (S) [A]	7/1/2008 (S) [A] 1/1/2009 1/1/2014(S)
Colorado	—	12/1/2009	8/10/2005 (S) [L] 12/1/2009 [A]	—
Connecticut	10/1/2005	10/1/2005	10/1/2005 [A]	—
Delaware	1/2/2011	1/2/2011	4/14/2005 [L]	4/14/2005 [L]
District of Columbia	7/1/2004	7/1/2004	7/1/2004 [L]	—
Florida	—	10/1/2013 (S)	—	—
Georgia	—	7/1/2010	7/1/2010 [A]	—
Hawaii	7/1/2013	7/1/2013	7/1/2013 [A]	—
Idaho	—	7/1/2012	—	—
Illinois	1/1/2014	1/1/2010	7/15/2005 [A,L] 1/1/2008 [A,L]	—
Indiana	—	7/1/2011	7/1/2009 [A]	7/1/2009 [A]
Iowa	—	7/1/2010 (S)	7/1/2010 [L]	7/1/2010 [L]
Kansas	—	7/1/2010	1/1/2010 [L]	—
Kentucky	—	7/13/2010	7/13/2010 [A]	—
Louisiana	—	7/1/2008 (S) 8/15/2010	7/1/2008 (S) [A,L] 8/15/2010 [A,L] Secondary for novice drivers 18 and older	—
Maine	–	9/28/2011	9/16/2003 [L]	9/19/2007 [L]
Maryland	10/1/2010 (S) 10/1/2013	10/1/2009	10/1/2005 (S) [L] 10/1/2010 (S) [A,L] 10/1/2012 (S) [A] 10/1/2013 [A]	10/1/2005 (S) [L] 10/1/2010 (S) [A,L] 10/1/2012 (S) [A] 10/1/2013
Massachusetts	—	9/30/2010	9/30/2010 [A]	—
Michigan	—	7/1/2010	3/28/2013 [L] Use of integrated voice-operated systems permitted	—
Minnesota	—	8/1/2008	1/1/2006 [L]	—
Mississippi	—	—	—	7/1/2009 [L]
Missouri	—	—	—	8/28/2009 [A]

	All-driver ban		Teenage-driver ban	
	Hand-held cellphone conversations	**Texting**	**Any hand-held and hands-free cellphone use**	**Texting**
Montana	—	—	—	—
Nebraska	—	7/14/2010 (S)	1/1/2008 (S) [A,L]	1/1/2008 (S) [A,L]
Nevada	1/1/2012	1/1/2012	—	—
New Hampshire	—	1/1/2010	—	—
New Jersey	7/1/2004 (S) 3/1/2008	3/1/2008	1/8/2002 [L]	1/8/2002 [L]
New Mexico	—	—	6/17/2011 [L]	6/17/2011 [L]
New York	11/1/2001	11/1/2009 (S) 7/12/2011	—	—
North Carolina	—	12/1/2009	12/1/2006 [A]	12/1/2006 [A]
North Dakota	—	8/1/2011	1/1/2012 [A]	—
Ohio	—	8/30/2012 (S)	8/30/2012 [A]	8/30/2012 [A]
Oklahoma	—	—	11/1/2010 [L] Prohibits hand-held phone use only	11/1/2010 [L]
Oregon	1/1/2010	1/1/2010	1/1/2008 (S) [A,L] 1/1/2010 [A]	1/1/2008 (S) [A,L] 1/1/2010
Pennsylvania	—	3/8/2012	–	—
Rhode Island	—	11/9/2009	6/29/2006 [A]	—
South Carolina	—	—	–	—
South Dakota	—	—	7/1/2013 (S) [L]	7/1/2013 (S) [L]
Tennessee	—	7/1/2009	7/1/2005 [L]	—
Texas	—	—	9/1/2005 [L] 9/1/2011 [A]	9/1/2005 [L] 9/1/2011 [A]
Utah	—	5/12/2009	5/14/2013 [A]	—
Vermont	—	6/1/2010	6/1/2010 [A]	—
Virginia	—	7/1/2009 (S) 7/1/2013	7/1/2007 (S) [A]	7/1/2007 (S) [A] 7/1/2013
Washington	7/1/2008 (S) 6/10/2010	1/1/2008 (S) 6/10/2010	6/10/2010 [L]	—
West Virginia	7/1/2012 (S) 7/1/2013	7/1/2012 (S) 7/1/2013	6/9/2006 (S) [A,L] 7/10/2009 [A,L]	6/9/2006 (S) [A,L] 7/10/2009 [A,L]
Wisconsin	—	12/1/2010	11/1/2012 [L]	—
Wyoming	—	7/1/2010	7/1/2007 [A]	—

Notes: Laws applying to a small subset of drivers (e.g., school bus drivers) or specific locations (e.g., school zones, work zones) are not noted. In states with all-driver texting bans and teenage-driver texting bans that differ, the law with the strongest provisions (i.e., age or license status covered, primary versus secondary enforcement) is noted. All-driver texting bans are noted in the novice driver texting ban column only if the all-driver ban upgraded enforcement type (California, Maryland, Oregon, Virginia).

(S) Indicates secondary enforcement; primary enforcement otherwise.

[A]Novice driver ban covers specific age group; [L]novice driver ban is licensing stage-based.

APPENDIX B

Summary of Peer-reviewed Papers or Technical Reports Evaluating Effects of Cellphone Bans in the United States on Crashes

Author(s), year	Dependent measure(s)	Basic study approach	Primary study period	Main findings	Main limitations
Studies of All-Driver Hand-held Cellphone Bans					
Bhargava, Pathania, 2013	State-level monthly rate of fatal crashes per 100,000 persons	Modeled fatal crash rate before/after bans were implemented in Connecticut, New Jersey, New York, District of Columbia, and Chicago with cellphone ownership (compared crash rates during 1989-1993, when cellphones were scarce, with rates during 2001-07) and set of control variables	1989-2007	No significant effect of bans on crash rates were found in full model	Although 1989-1993 is a period with far less cellphone ownership relative to 2001-07, it does not account for other period-relevant factors (e.g., vehicle safety, highway safety laws) that influence fatal crashes; unclear whether cellphone use, traffic volumes and crashes measured for same roadways and jurisdictions
Jacobson, King, Ryan, et al., 2012	County-level annual rates of injury crashes per licensed drivers	Modeled crash rates in New York before/after ban, with Pennsylvania as control, for 3 driver density county groups, based on number of licensed drivers per roadway mile	1997-2008	Relative to changes in Pennsylvania, significant increase in injury crash rates at onset of ban for suburban/urban and very rural counties and decreasing post-ban trend in injury crash rates in urban/suburban and rural counties	No empirical or theoretical support for method of categorizing counties; mechanism underlying varying effectiveness across counties of varying driver density is unclear
Kolko, 2009	State-level monthly rate of crash deaths per billion vehicle miles overall and in different conditions (e.g., wet roads, dry roads)	Modeled crash death rates with mobile phone ownership, hand-held cellphone ban status, and set of control variables across 48 contiguous states and District of Columbia	1997-2005	Bans not significantly associated with overall monthly crash death rate but significantly associated with lower estimated monthly crash death rates in bad weather or wet road conditions	Lack of data on vehicle miles travelled in specific driving conditions; brief post-law periods for most bans; longer term results based mainly on New York data
Lim, Chi, 2013a	State-level annual rates of crash deaths per miles traveled, number of drivers in fatal crashes per cap-	Modeled crash measures with all-driver hand-held cellphone ban with primary enforcement status and set of control variables across	2000-10	Hand-held bans with primary enforcement not significantly associated with fatality rates per miles traveled or per capita in the full models but significantly	Reduction for youngest drivers confounded by variations in states' teenage driver licensing laws over time; control group included states with secondary

Author(s), year	Dependent measure(s)	Basic study approach	Primary study period	Main findings	Main limitations
	ita, and number of drivers in fatal crashes for 8 different age groups	50 states and District of Columbia		associated with reductions in total number of drivers in fatal crashes and number of drivers in fatal crashes for age groups under 55	enforcement cellphone laws
Nikolaev, Robbins, Jacobson, 2010	County-level and state-level annual rates of fatal crashes and injury crashes per licensed drivers	*t*-tests comparing mean annual crash rates in New York localities before and after ban	1997-2007	Significant reductions in mean crash rates in most counties and statewide	No control group or other control for crash trends unrelated to ban
Sampaio, 2010	County-level annual rates of fatal crashes per licensed drivers	Modeled crash rates in New York before/after ban, with Pennsylvania as control	1997-2007	Reduction in fatal crash rate in New York significantly larger than reduction in Pennsylvania	Variation in county size not accounted for in model estimation
Trempel, Kyrychenko, Moore, 2011	State monthly insurance collision claims per insured vehicle year	Modeled claim rates before/after bans in California, Connecticut, New York, and District of Columbia, with 2 or more neighboring control states	18-33 months before and 12-29 months after bans effective	Nonsignificant small declines in claim rates in California and the District of Columbia relative to controls; significant small increases in Connecticut and New York	Unclear if collision claims are good indicator of distraction-related crashes, or if controls fully accounted for unobserved factors influencing claim rates
Studies of Texting Bans					
Abouk, Adams, 2013	State-level monthly single-vehicle, single-occupant fatal crash counts	Modeled single-vehicle, single-occupant fatal crash counts with strong texting ban status (primary enforcement, all-driver), weak texting ban status (secondary enforcement, all-driver, or covering only young drivers), and set of control variables in 49 states (excluding Alaska)	2007-10	Number of single-vehicle, single-occupant fatal crashes was lower in states with strong texting bans vs. states without bans, but not significantly so in the full model; number of single-vehicle, single-occupant fatal crashes was significantly higher in states with weak bans vs. states without bans in the full model	Multiple-vehicle or multiple-occupant fatal crashes used in some analyses as control, but these crashes also could involve texting drivers; several errors in information on state ban provisions and effective dates, leading to mistakes in the classification of state bans
Highway Loss Data Institute, 2010	State monthly insurance collision claims per insured vehicle year	Modeled claim rates before/after bans in California, Louisiana, Minnesota, Washington, with 2 or more neighboring control states	6-18 months before and 12-24 after bans effective	Significant increases in claim rates in California, Louisiana, and Washington relative to controls; no significant change in claim rates in Washington	Unclear if collision claims are good indicator of distraction-related crashes, or whether controls fully accounted for unobserved factors influencing trends in claim rates

Author(s), year	Dependent measure(s)	Basic study approach	Primary study period	Main findings	Main limitations
Studies of Multiple Types of Cellphone Bans					
Anyanwu, 2012	State-level annual crash deaths	Modeled number of state-level annual crash deaths with hand-held cellphone ban status, texting ban status, cellphone ban for drivers under the age of 20 status, cellphone ban for intermediate license holders status, and set of control variables across 50 states and District of Columbia	2000-09	All-driver hand-held cellphone bans were significantly associated with fewer fatalities in the full model, but no significant effects for other types of laws	Some laws incorrectly coded based on categories described; model included only a few control variables and may not have adequately accounted for unobserved factors that influence driving habits and crash fatalities
Lim, Chi, 2013b	State-level number of 14-20 year-old drivers in fatal crashes not involving alcohol	Modeled number of fatal crashes with cellphone ban status for novice or young drivers with primary enforcement, all-driver hand-held cellphone ban with primary enforcement status, and set of control variables across 48 contiguous states	1996-2010	Significantly fewer young driver fatal crash involvements associated with all-driver hand-held phone bans with primary enforcement, but no effects found for novice or young driver bans	Changes in exposure among teenage drivers during the study period unaccounted for; states with cellphone bans with secondary enforcement included as controls; short after periods for many bans